SMART AUTOMATION IN AQUACULTURE: RECENT ADVANCEMENTS AND FUTURE PROSPECTIVE

Article · November 2023

CITATIONS
0

READS
1,219

5 authors, including:

Ashutosh Danve
Central Institute of Fisheries Education
18 PUBLICATIONS **1** CITATION
SEE PROFILE

Mehulkumar Patel
Central Institute of Fisheries Education
4 PUBLICATIONS **0** CITATIONS
SEE PROFILE

Swaraj Adakney
Central Institute of Fisheries Education
17 PUBLICATIONS **0** CITATIONS
SEE PROFILE

Yash Khalasi
Central Institute of Fisheries Education
21 PUBLICATIONS **1** CITATION
SEE PROFILE

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Article ID : 03/XI/18/1123

SMART AUTOMATION IN AQUACULTURE: RECENT ADVANCEMENTS AND FUTURE PROSPECTIVE

Ashutosh Danve*, Mehul Patel, Swaraj Adakney, Yash Khalasi and Elina Vettom

[1]ICAR-Central Institute of Fisheries Education,
Mumbai, Maharashtra – 400061
*Corresponding Email: danveashutosh1@gmail.com

Abstract

With the continuous development of science and technology, intelligence and informatization in aquaculture has become a new trend. Smart aquaculture cannot only realize real-time monitoring, prediction, warning, and risk control of the physical and chemical factors of the aquaculture environment but can also conduct real-time monitoring of the characteristics and behaviours of the fish, which infers the changes of the aquaculture ecological environment. Smart automaton highlights different benefits for the aquaculture industries which includes monitoring and control systems, feeding operations, water quality managements, fish health assessment and harvesting processes. Smart automation includes the integration of artificial intelligence, robotics, Internet of Things (IoT), edge computing, 5G and advanced algorithms for real-time monitoring of fishes, efficient management of the water level and pumping functions, which ultimately leading to enhanced decision-making by liberating the manpower completely and realize the green and sustainable aquaculture. Smart Robotic systems equipped with vision-based sensors and robotic arms can accurately identify, sort, and harvest fish, minimizing stress and reducing labour-intensive manual operations. Additionally, advancements in automated data collection and management systems have enabled efficient tracking and analysis of production data, allowing optimization of processes, and improved overall farm management in aquaculture. While automation offers significant advantages, it also poses challenges related to initial investment costs, technical complexities, and potential job displacement. Moreover, there are ethical considerations regarding animal welfare and environmental impact that need to be addressed when implementing automation technologies in aquaculture. Therefore, by adopting and further developing these automation technologies, the aquaculture and fisheries sector can overcome operational challenges, improve profitability, and contribute to the high-quality production by providing valuable reference for promoting the smart, ecological and efficient development of the sector.

Introduction

Aquaculture, the farming of aquatic organisms such as fish, crustaceans, molluscs, and aquatic plants, is one of the fastest growing food sectors in the world. As the human population continues to grow exponentially, the demand for seafood is also increasing rapidly. Aquaculture is helping to meet this increasing demand in a sustainable manner. However, aquaculture operations require constant monitoring and control of various environmental parameters to optimize growth and ensure the health of cultured species.

This extremely complex task of setting up and maintaining the aquaculture industry requires fine-tuning many variables to produce an optimal outcome. Technology integrated with efficient algorithms helps create a framework for the intelligent aquaculture industry. (Vo, Et.al 2021). Therefore, smart automation in aquaculture aims to apply smart modes which solves problems in traditional aquaculture.

ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in
Peer reviewed
monthly newsletter

Recent advancements in sensors, monitoring equipment, and control systems are facilitating increased automation of aquaculture systems. Water quality sensors can continuously monitor parameters such as dissolved oxygen, pH, temperature, and salinity. Cameras and computer vision techniques enable monitoring of fish behaviour and growth. All of these sensors and monitoring systems are connected to control systems that can automatically control factors such as water flow, aeration, feeding, and lighting based on the sensor data. Automated feeding systems can provide fish with optimal feed amounts at the right times based on fish growth stage and environmental conditions. Automated grading and harvesting systems can efficiently handle and process fish once they reach market size. (Lloyd Chrispin 2020). Smart automation technologies are enabling aquaculture farms to gain more control and improve efficiency.

While automation is enabling increased efficiency, control, and productivity of aquaculture operations, there are challenges to overcome. Automation equipment can be expensive, especially for smaller scale farms, although costs are coming down over time. There is also a learning curve for farmers to understand and utilize these advanced systems. Data connectivity and management is another issue, as many aquaculture farms are located in remote areas.

The future of smart automation in aquaculture is promising. Advancements in artificial intelligence, edge computing, and 5G connectivity will enable new capabilities such as predictive analytics to optimize system control and gain valuable insights. Robots may take over dangerous and repetitive tasks such as net cleaning and harvesting. Drone and satellite monitoring could provide aquaculture farms with real-time data on environmental conditions over large areas.

Automation Function in Aquaculture

Table 1. Function of automation in aquaculture.

	Predict	Automate
Water	Water Quality Threats	Aeration, Water Quality measures
Health	Disease Outbreaks	Predicts Parasites, symptoms, monitor disease and health
Production	Forecast Growth	Estimation of Biomass, Feed Optimization, Counting

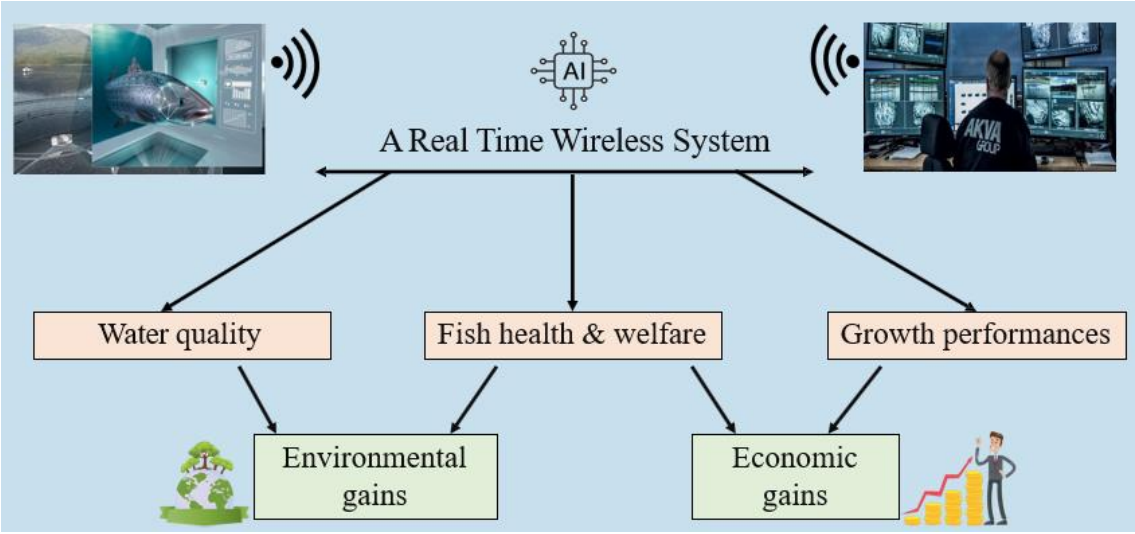

Fig. 1. System of Automation in Aquaculture

Body

Smart aquaculture systems use sensors, actuators, and intelligence technologies to provide an automated and sustainable system for raising aquatic organisms. These systems involve the use of sensors and other technologies to control factors such as lighting, pH balance, temperature, and oxygen levels, as well as the size and density of the population of organisms in the tank.

Technologies in Automation

❖ **Water Quality monitoring**

Sensors can monitor important water quality parameters like pH, dissolved oxygen, temperature, nitrite and ammonia levels (Nguyen et al., 2022). Machine learning models can analyse the sensor data to detect abnormal conditions and predict future changes (Nguyen et al., 2022). This allows farmers to proactively adjust aeration, feeding and water treatment to maintain optimal conditions for fish growth.

Intelligent fish farm collects water quality information using sensors.
Regulated by: fertilizing and spraying chemicals on unmanned boat.

Long-time accurate detection of aquaculture water quality parameters provides a reliable data source for automatic control and intelligent decision-making of intelligent fish farm.

The detection of DO mainly includes the Clark electrode method (Tai et al., 2016).

Advantages

- Fast response time
- Stable measurement results
- Low maintenance (Tai et al., 2016).

❖ **Feed management**

AI systems use data from sensors, cameras and fish behaviour to optimize feeding schedules and amounts (Vásquez-Quispesivana et al., 2022). Factors like fish size, activity levels and water conditions are taken into account to ensure fish receive the right amount of feed (Vásquez-Quispesivana et al., 2022). This improves feed efficiency, reduces waste and minimizes environmental impacts.

Automatic feeding system in some developed countries such as Norway, Japan, and the United States has entered the application stage, which has achieved accurate controlled feeding (Wang et al., 2021).

Reduces FCR: Reduces FCR by 30%, profit margins will only go upwards! (Davis et al., 2018).

Advantages

- Appetite Based Intelligent Feeding
- Superior Production Performance
- 24 x 7 Feeding System
- Reduced Feed Wastage
- Homogenous Growth
- Less Pollution

❖ **Disease detection**

Machine vision systems use cameras and image processing algorithms to detect diseases and abnormalities in fish. They can identify symptoms like skin lesions, deformities, and discoloration that indicate diseases (Vo et al., 2021). This allows farmers to intervene early before diseases spread. The same systems can also sort fish by size, weight and quality for more efficient sale and harvest (Vo et al., 2021).

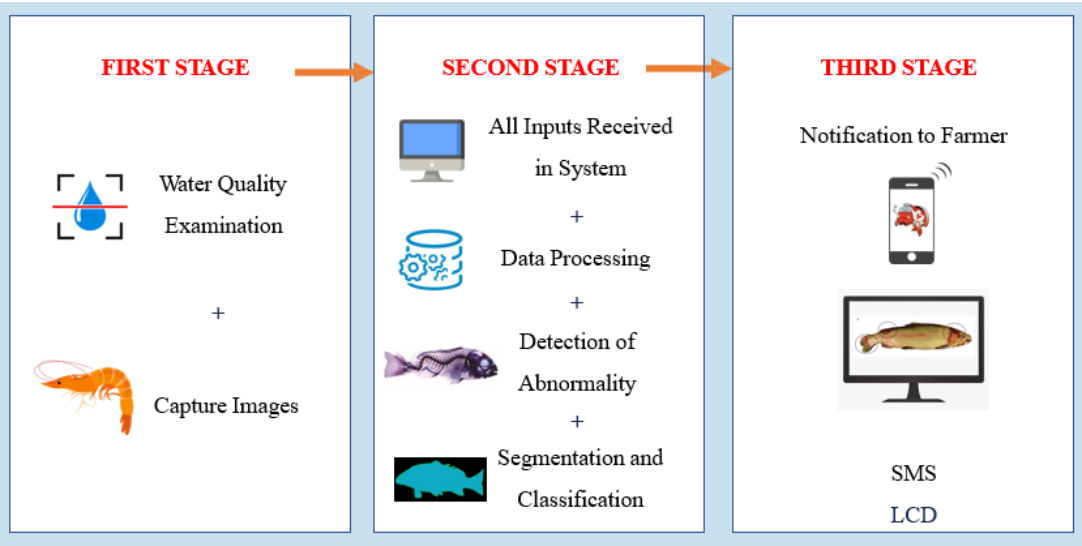

Fig. 2. Process of health management with the help of automation.

Advantages

- Early Detection of Diseases.
- Regular behaviour check-up.
- Early warnings notifications.

Future Prospective

- As machine learning, computer vision, IoT, and robotics technologies continue to improve, they are likely to play an even greater role in automating aquaculture farms and optimizing production. Areas of potential future development include:
- Fully automated fish tracking and behaviour analysis to optimize stocking density and welfare.
- Advanced disease detection using deep learning models trained on large datasets.
- Fully automated aquaculture systems controlled by AI with minimal human intervention.
- Use of drones and autonomous underwater vehicles to monitor aquaculture ponds.
- Integration of blockchain and cloud technologies for traceability and remote farm management.

Benefits of Automation in Aquaculture

- Origin of production close to the market demand
- Improved environmental control
- Reduced losses caused by major disasters
- Reduced management environment
- Lower production costs
- Improved aquatic product quality
- Reduced costs of production
- Reduced energy consumption
- Reduced staffing
- Reduced workload
- Reduced control
- Increased overview

- Increased security
- Increased fish welfare

Conclusion

Smart automation and intelligence systems have the potential to transform aquaculture by improving yields, reducing costs, and promoting sustainability. Recent technological advancements are enabling greater automation, but high costs currently limit adoption. As technologies continue to improve and costs decline, smart aquaculture systems are poised to play an increasingly important role in meeting the world's growing demand for seafood.

References

Vo, D. V., Nguyen, H. T., Dinh, T. T., Nguyen, T. T., & Dao, B. C. (2021). Smart aquaculture 4.0: A comprehensive review. Aquaculture and Fisheries, 6(2), 75-84.

Vásquez-Quispesivana, Z., Alvarado, J. C., Callupe, C., & Córdova, A. (2022). Smart aquaculture: A review of artificial intelligence applications. Aquaculture Reports, 22, 100789.

Nguyen, H. T., Vo, D. V., Nguyen, T. T., & Dao, B. C. (2022). Smart aquaculture: A review of recent advances and future prospects. Aquaculture Reports, 24, 101117.

Zhao, Y., Wang, Y., Li, Y., & Wang, Y. (2021). Smart aquaculture: A review of recent advances and future prospects. Aquaculture and Fisheries, 6(1), 1-10.